



## Problem Statement and Goals

### RoCam

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Table 1: Revision History

Date	Developer(s)	Change
Sept. 8, 2025	Jianqing Liu	Initial Draft
Sept. 9, 2025	Zifan Si	Details Elaboration
Sept. 10, 2025	Zifan Si	Fix based on teammate suggestion
Sept. 10, 2025	Jianqing Liu	Refine inputs, outputs, and goals
Sept. 12, 2025	Jianqing Liu	Update Depolyment Environment
Sept. 13, 2025	Xiaotian Lou	Update Citation

# 1 Problem Statement

## 1.1 Problem

In model rocketry, two of the hardest engineering problems are staging failures and parachute tangling. These problems are hard to study because they happen in mid-flight, where direct observation is limited. Without reliable tracking, engineers cannot fully understand these failures or design better solutions. As a result, recurring issues remain unresolved, slowing progress in both safety and performance of future rockets.

Model rockets travel at very high speeds, sometimes faster than Mach 3 and over 100 km in altitude ([Space Concordia, 2025](#)). Under these conditions, manual camera tracking is not possible.

Tracking a small model rocket is even harder than tracking large rockets such as the Falcon 9. Smaller size and uncontrolled launch conditions make accurate detection and continuous tracking much more difficult.

Some commercial tracking systems exist ([AVe, 2021](#)), but they do not have the accuracy or speed needed to follow small, fast-moving rockets. This gap shows the need for a dedicated system that can provide clear, real-time observation of rocket flights.

## 1.2 Inputs and Outputs

- **Inputs**

- Realtime camera feed
- State information from gimbal
- Manual camera gimbal adjustment commands from user

- **Outputs**

- Camera gimbal adjustment commands to maintain visual lock of the rocket
- Realtime video preview via ethernet
- Realtime stabilized video output via HDMI with the rocket centered in frame
- Recorded video with the rocket centered in frame

## 1.3 Performance Objectives

- System should be able to handle 1080p 60fps camera feed
- System should be able to output 1080p 60fps video via HDMI
- Realtime video preview should be at least 15fps

## 1.4 Stakeholders

### Direct Stakeholders

1. **McMaster Rocketry Team:** The primary end users who will deploy the system during launches. They depend on accurate real-time tracking to analyze staging, parachute deployment, and overall flight performance.
2. **Dr. Shahin Sirouspour (Supervisor):** Provides technical guidance, project oversight, and mentorship. Ensures the project aligns with academic standards, engineering best practices, and capstone deliverable expectations.

## Indirect Stakeholders

1. **Aerospace Engineers and Researchers:** Benefit from high-quality flight footage to validate models, improve rocket designs, and support experimental research.
2. **Event Organizers and Safety Officers:** Rely on reliable tracking for live monitoring of rocket flights, particularly for confirming parachute deployment and safe recovery during launch events.
3. **Engineering and Robotics Community:** May adapt the system's design principles for other domains requiring precise tracking of fast-moving objects, such as UAV navigation, sports analytics, or autonomous robotics.
4. **Potential Commercial and Industrial Users:** Could adopt the system for broader applications in surveillance, wildlife monitoring, or industrial inspections where real-time vision-guided tracking is valuable.

## 1.5 Environment

### Deployment Environment

- Outdoor rocket launch sites with variable lighting, wind, and dynamic backgrounds.
- Initial testing on small-scale model rockets (apogees around 200 m).
- Scalable to high-powered launches by the McMaster Rocketry Team (apogees exceeding 3 km).
- Indoor lab-based testing and demonstration for development and evaluation.

### Execution Environment

There are four pieces of the hardware related to this project:

1. A gimbal with a camera mounted on it
2. An STM32 microcontroller
3. An Nvidia Jetson processing module
4. An user laptop running a browser connected to the Jetson

Three pieces of software will be developed as a part of this project:

1. Baremetal code that runs on the STM32 microcontroller
2. Code that runs on the Jetson, which expects an linux environment with JetPack 6
3. Code that runs on the user browser, which expects any recent versions of major browsers

## 2 Goals

The goal of the project is to track small-scale model rocket launches with apogee  $< 200\text{m}$ , while achieving all the performance objectives listed in Section 1.3.

### 3 Stretch Goals

- Handle 4K 60fps camera stream.
- Include functionalities to control the zoom and the focus of more advanced cameras.
- Integration with a full-size gimbal developed by the McMaster Rocketry Team.
- Track high-powered model rocket launches (apogee 3km+), while achieving all the performance objectives listed in Section [1.3](#).

## 4 Extras

### 4.1 Circuit Design

As this project require to use of a mechanical gimbal, electrical circuit is needed to interface between the host computer and the actuators. A seperate document will be authored to detail the circuit design.

### 4.2 User Instructional Video

An user instructional video will be created to help potential users to understand how to use the system.

## Appendix — Reflection

The purpose of reflection questions is to give you a chance to assess your own learning and that of your group as a whole, and to find ways to improve in the future. Reflection is an important part of the learning process. Reflection is also an essential component of a successful software development process.

Reflections are most interesting and useful when they're honest, even if the stories they tell are imperfect. You will be marked based on your depth of thought and analysis, and not based on the content of the reflections themselves. Thus, for full marks we encourage you to answer openly and honestly and to avoid simply writing "what you think the evaluator wants to hear."

Please answer the following questions. Some questions can be answered on the team level, but where appropriate, each team member should write their own response:

1. What went well while writing this deliverable?
2. What pain points did you experience during this deliverable, and how did you resolve them?
3. How did you and your team adjust the scope of your goals to ensure they are suitable for a Capstone project (not overly ambitious but also of appropriate complexity for a senior design project)?

### Jianqing Liu

I'm responsible for drafting most of the sections of this deliverable except stakeholders and environment. Section 1.1 "Problem" is actually the most difficult section to write, as the field of model rocketry is not familiar to most people. I showed that section to multiple people and modified it based on the feedback. I had to add a "Performance Objectives" section to further specify the "high-performance" part of the project, which is not in the original template, but I think it worked out well. I had some disagreements with my teammates on the environment section, but we cleared up the differences by talking to a TA. Luckily, no adjustments to the project goals were needed.

### Xiaotian Lou

***What went well while writing this deliverable?*** Our team started with a clear objective and a lightweight task management plan, which helped keep ownership visible and discussions focused. We also successfully connected with a faculty advisor relevant to our domain. Team communication was smooth and inclusive; ideas were surfaced early, discussed openly, and consolidated into a shared view without blocking progress.

***What pain points did you experience during this deliverable, and how did you resolve them?***

Authoring in L<sup>A</sup>T<sub>E</sub>X was initially time-consuming and a bit frustrating. We mitigated this by adopting editor plugins, templates, and a simple compile pipeline. Conceptually, a few sections felt vague at first; we resolved this through multiple short meetings, refining definitions, assumptions, and success criteria until the problem framing was concrete.

### 4.3 Shike Chen

The team is very cohesive with a clear goal on our project. It was very easy for us to identify our objectives. The only struggle involved in this deliverable is the standards to "high-performance". The definition of "high-performance" largely dictates the complexity of the project. In order to constrain the scope of the project and ensure the project is suitable for a Capstone project, we added some constraints and extra goals to confine the domain of "high-performance".

## References

*AI Auto Tracking PTZ Camera TR3XX Series User Manual*. AVer Information Inc., October 2021. Version 1 (2021-10-15).

Space Concordia. Space concordia rocketry. <https://web.archive.org/web/20250717115148/https://spaceconcordia.ca/rocketry>, 2025. Archived 2025-07-17; accessed 2025-09-13.